INHOMOGENEOUS AND NONSTATIONARY FEATURE ANALYSIS: MELDING OF OCEANIC VARIABILITY AND STRUCTURE (INFAMOVS)

Dr. Arthur J. Mariano
RSMAS, MPO, University of Miami
4600 Rickenbacker Cswy
Miami, FL 33149
phone: 305-361-4193 fax: 305-361-4622 e-mail: amariano@rsmas.miami.edu

Dr. Toshio M. Chin
RSMAS, MPO, University of Miami
4600 Rickenbacker Cswy
Miami, FL 33149
phone: 305-361-4816 fax: 305-361-4622 e-mail: tchin@rsmas.miami.edu

Award #: N00014-95-1-0257

LONG-TERM GOALS

One of the primary research goals at RSMAS is real-time forecasting of both Eulerian fields, such as temperature and velocity, and Lagrangian trajectories. The five primary components are (i) MICOM, the Miami Isopycnal Coordinate Ocean Model, (ii) satellite-derived sea surface temperature and height fields and data from Lagrangian drifters, (iii) an Extended Kalman Filter (EKF) with a second-order Gauss-Markov Random Field (GMRF) model for spatial covariances, (iv) a random flight turbulence model for Lagrangian trajectory prediction, and (v) contour-based parameter estimation and assimilation techniques.

OBJECTIVES

Documenting, understanding, and predicting ocean variability through the use of new data analysis and assimilation techniques.

APPROACH

Our data analysis and assimilation approaches are based on motion-compensated space-time interpolation algorithms, state space reduction techniques, hodography, and multi-scale field decomposition.

WORK COMPLETED

The primary task completed in the last year is the extensive testing of an GMRF algorithm to a suite of simple but realistic highly nonlinear fluid flow problems (Chin et al., 1997) and application to a multi-layer MICOM double gyre simulation. Prediction errors and filter performance were evaluated for a suite of updating strategies, subspace projections/ covariance parameterizations, initial conditions, data sampling, and model variance to measurement variance ratios. Initial experiments with realistic coastlines and topography have begun.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1997**	2. REPORT TYPE	3. DATES COVERED **00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE **Inhomogeneous and Nonstationary Feature Analysis: Melding of OCeanic Variability and Structure (Infamovs)**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Miami,Rosensteil School of Marine and Atmospheric Science,4600 Rickenbacker Causeway,Miami,FL,33149**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**10**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

A procedure for estimating mean flow and diffusivity parameters in nonstationary and heterogeneous flows has been formulated, successfully tested, and applied to surface drifters in the tropical Pacific (Bauer et al., 1997).

An algorithm for applied Lagrangian prediction has been tested in model simulations and Gulf Stream search and rescue simulations with real drifter data with encouraging results (with A. Griffa, D. Olson, T. Ozgokmen, L. Piterbarg (USC)).

Daily scatterometer winds were interpolated in space using a multi-resolution wavelet technique that enhanced, between swaths, the high wavenumber component of the wind fields allowing for more realistic forcing of ocean circulation models (Chin et al., 1997).

Online regional and global data sets are available through an ftp site at playin.rsmas.miami.edu. Satellite-derived global sea surface temperature fields at 18 km, 2 day resolution for 1985-95 will be the next data product put online.

Development and application of a Kalman-smoother space-time frontal interpolator (Mariano and Chin, 1996; Chin and Mariano, 1997) to Gulf Stream (Mariano et al., 1997) and Kuroshio path data.

The parameter matrix OA algorithm was applied to altimeter and sea surface temperature data in the South Atlantic (Garzoli et al., 1997), coastal data along the Mississippi delta (Hitchcock et al., 1997), biological data in the Gulf Stream (Mariano et al., 1996), and data from Hurricane Gilbert (Shay et al., 1997). In each of these regional studies, the parameter matrix OA algorithm was an important analysis tool for the study of ocean variability.

A general stability analysis was performed by A. Moore (CSU) on a subset of the Gulf Stream Northern Edge Position data set (Moore and Mariano, 1997).

RESULTS

The GMRF-based Kalman filter is a stable and robust algorithm for the assimilation of sea surface height data and for "generalized" data. Shown in figures 1, 2, and 3 are results from a four-layer strongly nonlinear double gyre MICOM run that assimilated simulated Topex/Poseidon sea-surface height data. Figure 1 shows the estimates for the top layer (a) and bottom layer (b) at Day 12, after one complete Topex/Poseidon repeat cycle. The top panel is the "truth", the middle panel is the field with assimilation, and the lower panel is the spin-up with no data assimilation. The middle panels clearly show the effects of assimilated layer-thickness data. At Day 180 (fig. 2a, top layer; fig. 2b, bottom layer), the features in the "truth" (top panels) have been reproduced well in the fields with assimilation (middle panels) clearly displaying advantages over the run started with the same initial condition but without data assimilation (bottom panels). Figure 3 shows the corresponding root-mean-squares errors in time for the assimilation run, displaying an exponential decay of estimation error typical of Topex/Poseidon sea-surface height assimilation.

Preliminary results from Lagrangian data assimilation experiments indicate that in non-energetic regions with good historical data coverage, climatological mean fields and an AR(1) model for the turbulent velocity leads to accurate trajectory prediction. Accurate predictionin energetic regions, like the Gulf Stream, requires assimilation of high density contemporaneous data and AR(2) models for the turbulent velocity (see progress report by A. Griffa for further details).

Documentation of significant subannual, annual, and interannual variability of the path of the Gulf Stream continues with new data from Peter Cornillon (URI) (Mariano and Chin, 1996; Mariano et al., 1997).

A generalized stability analysis of Gulf Stream paths showed that initial uncertainties in the position of the Gulf Stream path are most amplified in regions of developing meanders with significant shearing and straining (Moore and Mariano, 1997).

Multi-resolution wavelet techniques interpolated along-swath high-wavenumber energy from scatterometer winds to between-swath locations. The interpolated wind fields were used to force models of ocean circulation at higher resolution than previously possible (Chin et al., 1997).

IMPACT/APPLICATIONS

Our work continues to be well reviewed by the oceanographic community and constitutes significant advances in data analysis and assimilation. We believe that this work will lead to improved ocean forecasts that will save lives and resources.

TRANSITIONS

In the last two years, algorithms and software have been sent to FNMOC and NRL. Figures of mean global sea surface temperature and velocity were used by W. Schmitz in both ONR-funded volumes on The World Ocean Circulation. As detailed in previous reports and evident in the list of co-authors below, we have freely exchanged our new ideas, software, and data products with Navy and Navy-sponsored scientists.

RELATED PROJECTS

Mariano and Chin are affiliated with the RSMAS remote sensing group and work closely with the MICOM modeling group. Strong collaboration with RSMAS scientists A. Griffa, D. Olson, T. Ozgokmen, as well as, M. Swenson (AOML), and L. Piterbarg (USC) on applied Lagrangian prediction will continue to be one of our primary near-term research activities.

Algorithms for predicting Lagrangian trajectories are being evaluated by T. Schneider, a RSMAS graduate student and officer in the US Coast Guard. Work with M. Radu-Rosu (UNC), R. Adler (UNC), and L. Piterbarg (USC) on phase speed estimation algorithms for global satellite data sets continues.

REFERENCES

Bauer S., M. Swenson, A. Griffa, A. Mariano and K. Owens, 1997: Eddy-mean flow decomposition and eddy-diffusivity estimates in the Tropical Pacific Ocean. Submitted to J. Geophys. Res.

Chin,T. M. and A.J. Mariano. Space-time Interpolation of Oceanic Fronts, 1997: IEEE, Trans. on Geosciences and Remote Sensing., 35(3), 734-746.

Chin, T.M., R.F. Milliff, and W.G. Large, 1997: Basin-scale, high-wavenumber sea-surface wind fields from a multiresolution analysis of scatterometer data. Accepted, J. Atm. Ocean. Tech.

Chin, T.M., A.J. Mariano and E.P. Chassignet, 1997: Spatial regression with Markov Random Fields for Kalman filter approximation in least-squares solution of oceanic data assimilation problems. Submitted to J. Geophys. Res.

Garzoli, S.L., G.J. Goni, A.J. Mariano and D.B. Olson, 1997: Monitoring the Upper Southeastern Atlantic Transports Using Altimeter Data. Journal of Marine Research., 55, 453-481.

Hitchcock, G.L., W.L. Wiseman, Jr., W.C. Boicourt, A.J. Mariano, N. Walker, T. Nelsen and E.H. Ryan, 1997: Property fields in the effluent plume of the Mississippi River. Journal of Marine Systems, 12, 109-126.

Mariano, A.J., G.L. Hitchcock, C.J. Ashjian, C. Flagg, D. Olson, T. Rossby, E.H. Ryan, and S. Smith, 1996: A principal component analysis of Bio-physical Fields in a Gulf Stream Meander Crest. Deep-Sea Research, 43(9), 1531-1565.

Mariano, A.J. and T.M. Chin, 1996: Feature and Contour Based data Analysis and Assimilation in Physical Oceanography. "Stochastic Modelling in Physical Oceanography", (Alder, Muller, and Rozovskii, eds.) Birkhauser, 311-342.

Mariano, A.J., T.M. Chin and E.H. Ryan, 1997: On Gulf Stream Path Variability . (In prep.)

Moore, A.M. and A.J. Mariano, 1997: The Dynamics of Error Growth and Predictability in a Model of the Gulf Stream. I: Singular Vector Analysis. J. Physical Oceanography. (In press).

Shay, L.K., A. J. Mariano, S.D. Jacob, and E. H. Ryan. Mean and Near-Inertial Ocean Current Response to Hurricane Gilbert. J. of Physical Oceanography. (In press).

http://www.rsmas.miami.edu/people/amariano

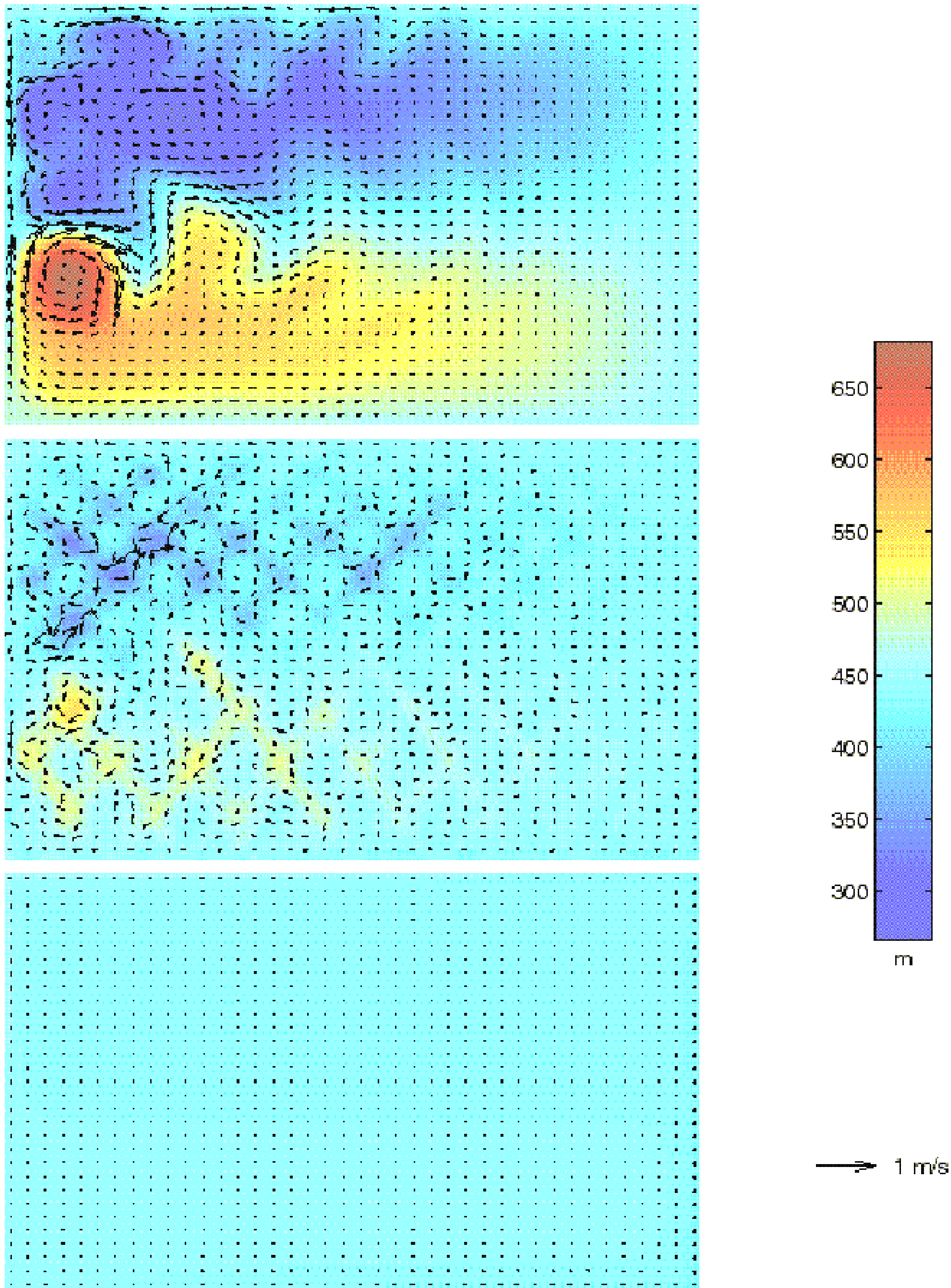

Figure 1

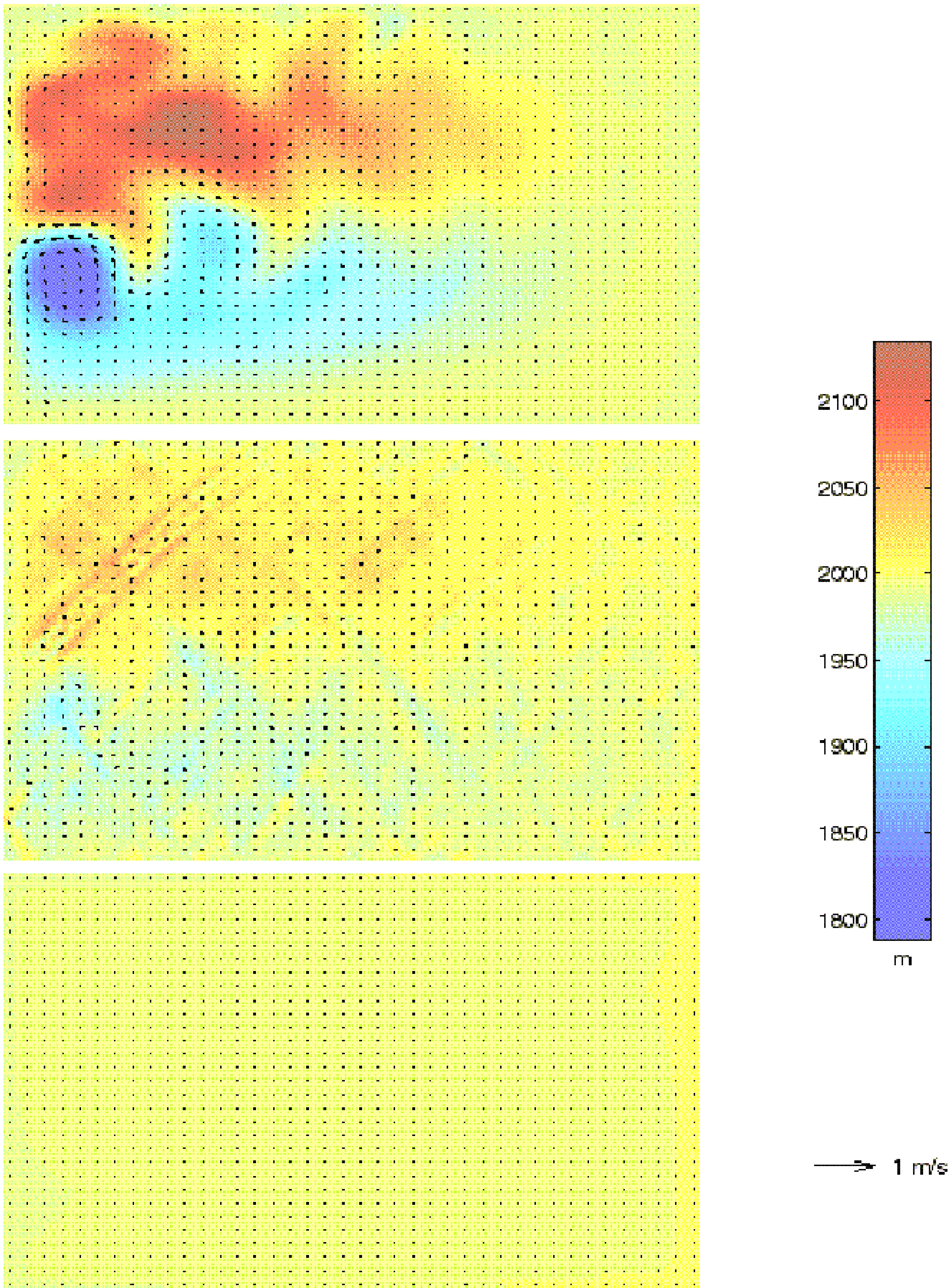

Figure 2

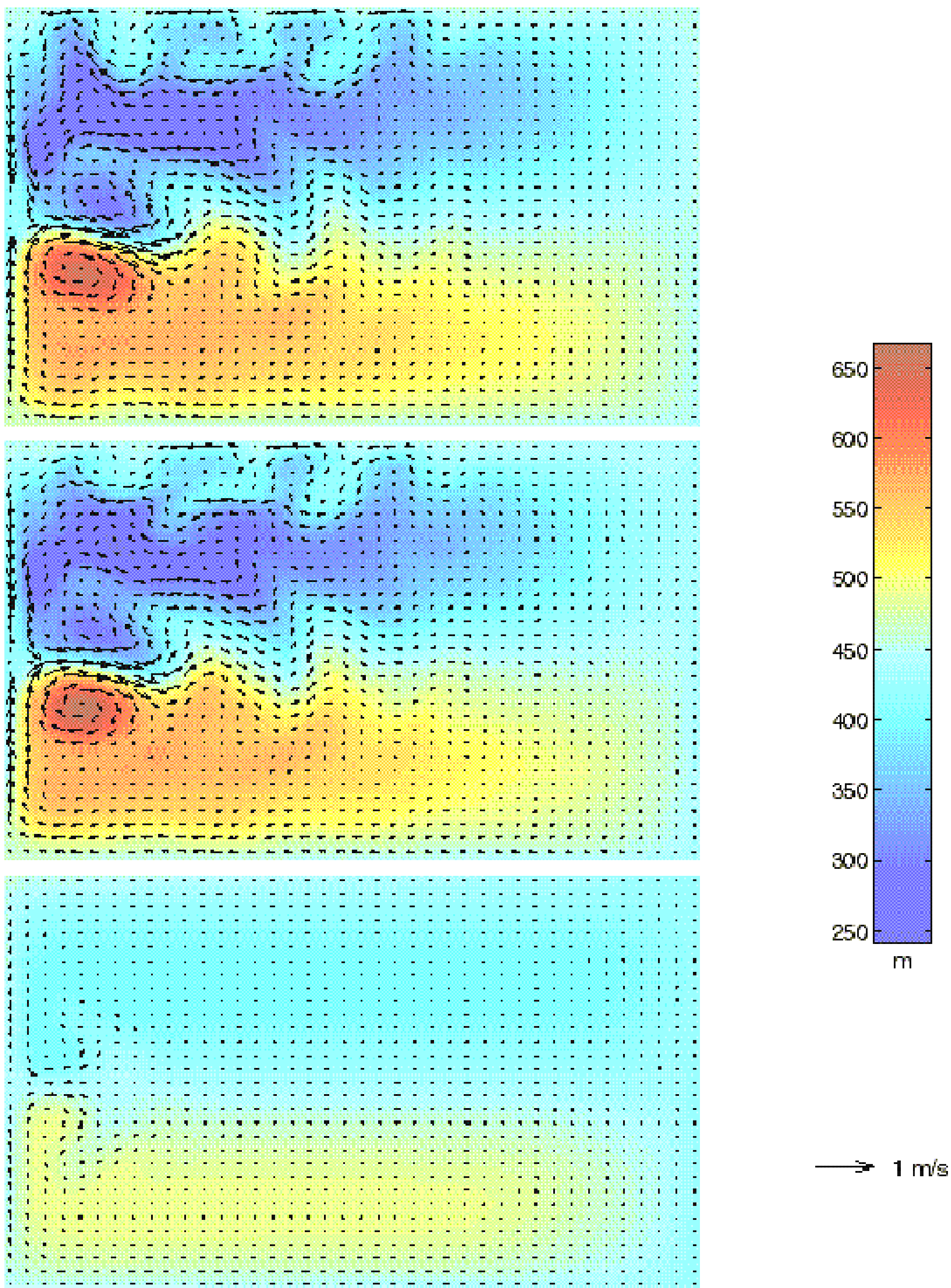

Figure 3

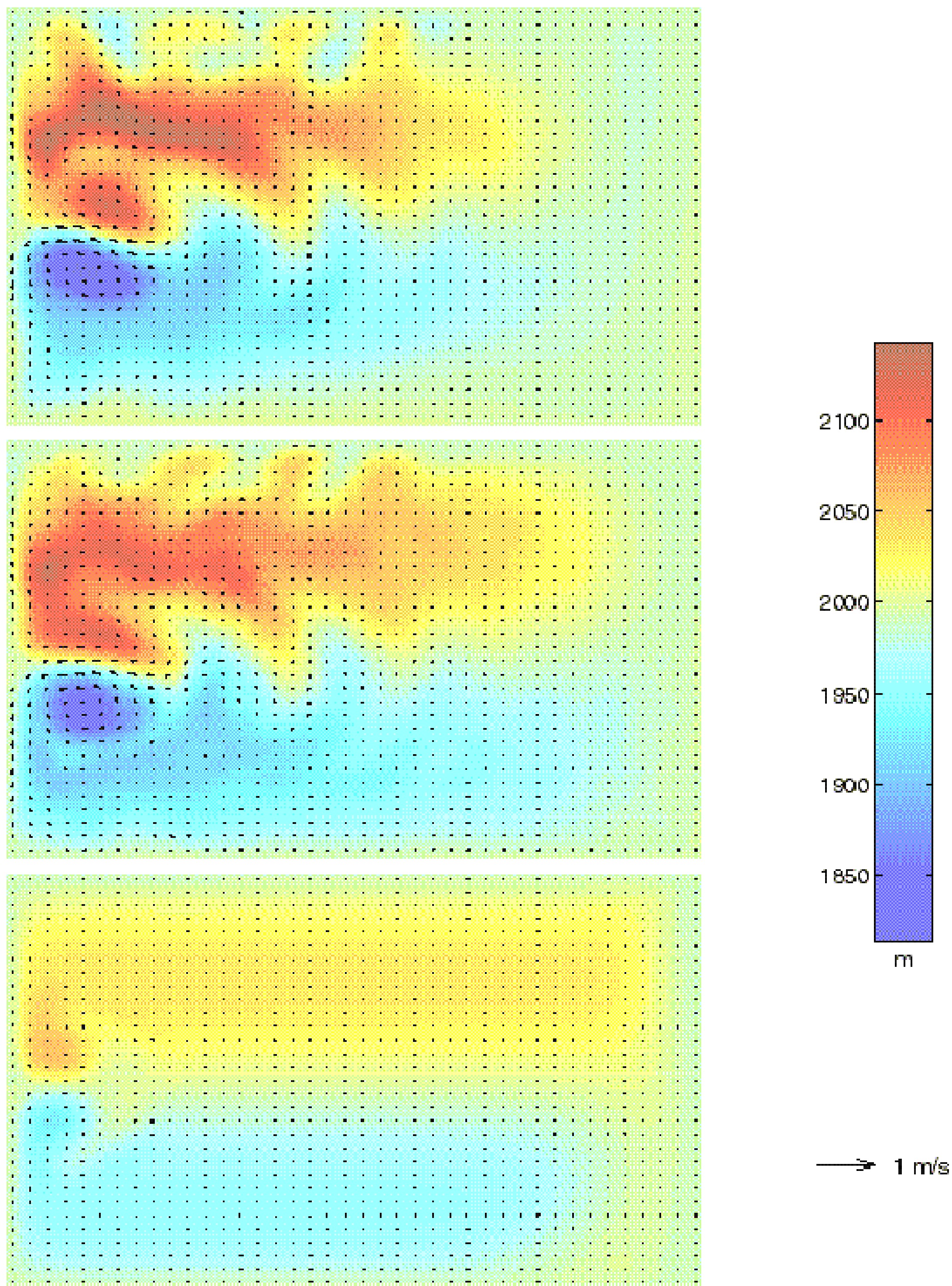

Figure 4

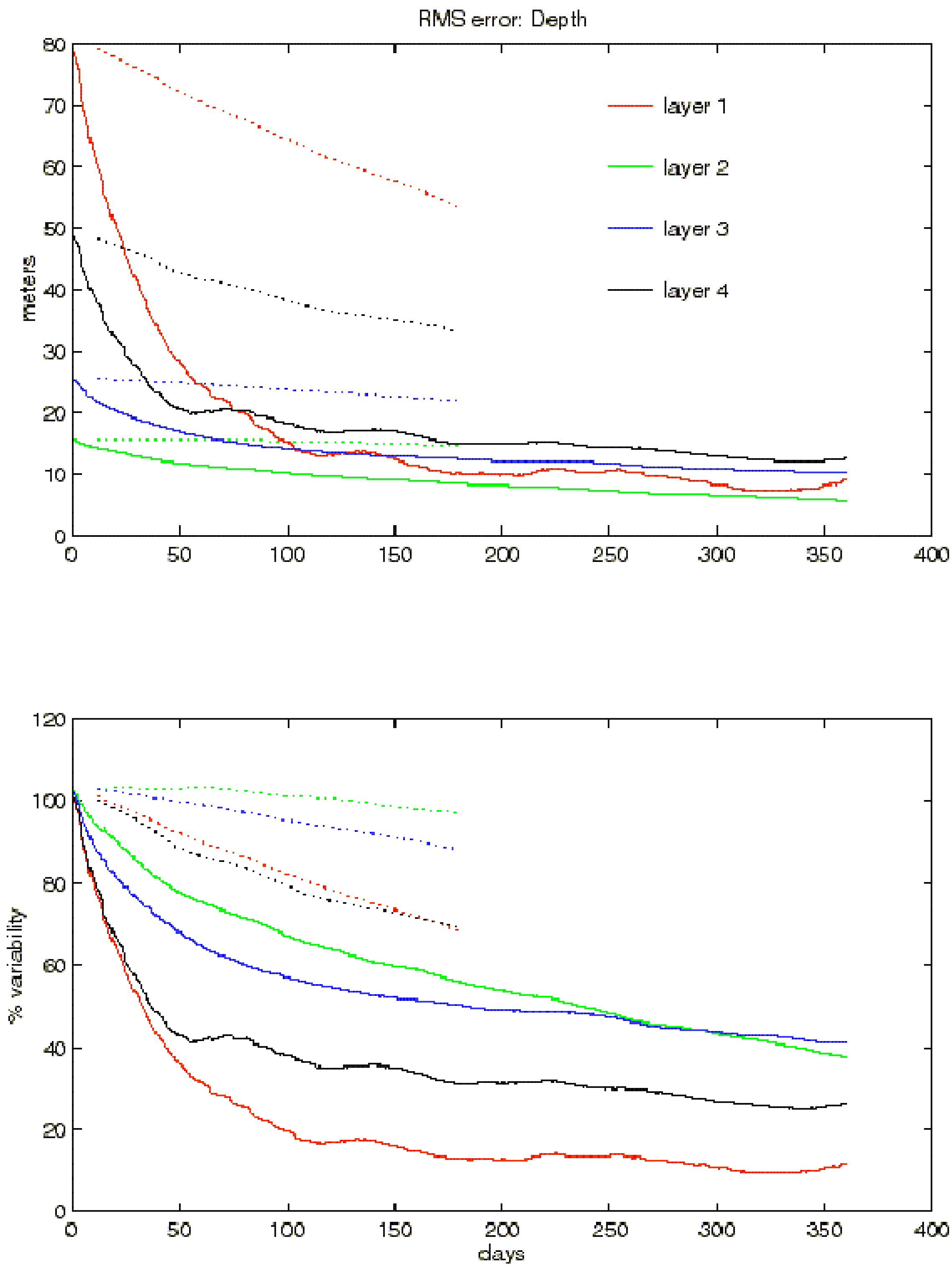
RMS error: Depth
meters
layer 1
layer 2
layer 3
layer 4
% variability
days
0
50
100
150
200
250
300
350
400
10
20
30
40
60
70
80
120

Figure 5

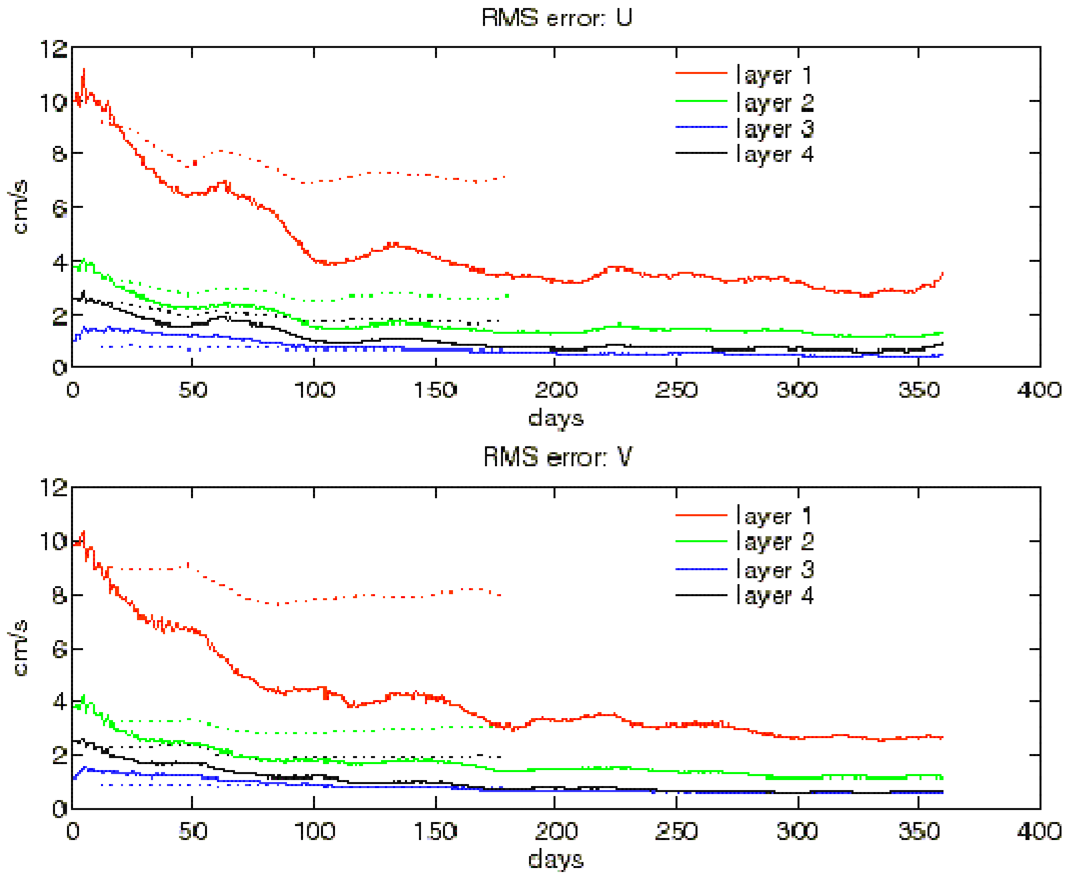
RMS error: U
layer 1
layer 2
layer 3
layer 4
cm/s
days
RMS error: V
layer 1
layer 2
layer 3
layer 4
cm/s
days

Figure 6